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Indenture as a Self-Enforced Contract Device:

An Experimental Test[*]

Alexander S. Kritikos[§] and Jonathan H.W. Tan[†]

Abstract

We experimentally test the efficacy of indenture as a self-enforced contract device. In an indenture game, the principal signals the intention of payment-on-delivery, by tearing a banknote and giving the agent half of it as "prepayment"; the agent receives the completing half after delivering the service. By forward induction, cooperation is incentive-compatibly self-enforcing. The indenture performs very well, inducing a significantly higher level of cooperation than that in a three-stage centipede game, which we use to benchmark the natural rate of cooperation. The difference between cooperation rates in both games increases over time.

Keywords: Cooperation, Experiment, Contracts, Indenture, Reciprocity

JEL Classification: C91, D64, J41.

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1. Introduction

How can a principal (an agent) ensure that an agent (principal) will work (pay) if payment (work) precedes work (payment)? An effective contract binds the contracted parties to honor the agreed terms-of-trade. Besides preventing moral hazard, its administration cost should ideally be as low as possible. The diversity of contracts can be classified under: i) contracts enforced by costly third party administration (e.g. the law), and; ii) contracts that are self-enforced by the contracting parties. While contracts with third party enforcement might suffer from prohibitive enforcement costs, self-enforced contracts can govern self-interested individuals with conflicting interests to complete successful economic transactions.[1]

Recent empirical research finds, however, that complete contracts driven by extrinsic incentives, i.e. monetary payoffs, to induce cooperation have their own limitations. These kinds of contracts potentially diminish the intrinsic motivation to cooperate voluntarily (Frey, 1997; Bénabou and Tirole, 2003).[2] Therefore, contracts of a polar opposite nature of complete contracts were considered. Explicit contracts based purely on intrinsic motivation such as trust and reciprocity have proven to be reliable, and may even outperform complete contracts in certain contexts (e.g., Falk and Kosfeld, 2006; Fehr et al., 1993, 1997; Güth et al., 1998). However, these positive results might not always hold.[3] For instance, trust and reciprocity can induce considerable levels of cooperation in trust games even when theory predicts defection (e.g. Berg et al., 1995; Bolle, 1998; Dufwenberg and Gneezy, 2000; Charness, 2004), but the stability of such contracts is suspect over time. Convergence to non-cooperation may occur if the game is played repeatedly (Zauner, 1999).

In this context, the present article experimentally tests for the first time the efficacy and the performance of the *indenture game* (*IG*) proposed by Kritikos and Bolle (1998) which is a self-enforced contract, incentive-compatible in one-shot interactions where reputation plays no role. The IG attempts to combine the low costs of self-enforcement, reliability of incentive-compatibility, and intrinsic motivations of trust and reciprocity. In the IG, the principal transfers the first half (of an indentured, i.e. torn, banknote) to the agent. The agent then decides whether to exert effort. The principal can complete the transaction by sending the other half of the indentured banknote to the agent. Kritikos and Bolle theoretically show that cooperation is a mutual best reply for principal and agent. Amongst the multiple equilibria, forward induction (van Damme, 1989) selects cooperation as the unique *stable* equilibrium – cooperation is thus self-enforced.

The central features of this contract are: a principal sends a signal of his intention to cooperate (paying up ultimately) by sending the agent the first half of an indentured note. Following the reasoning of Berg et al.'s (1995) trust game, it is also an investment of trust in the agent. Agents will interpret this action as a signal of intention to cooperate, by forward induction logic, and thus will accept the contract; in effect, they naturally self-select themselves into performing the task. As with the trust game, the fulfillment of tasks is positive reciprocity to the principal if the first half of the indenture is perceived as trust invested in the agent. In the final stage of the game, although the principal is indifferent between transferring and retaining the second half of the indentured note, it is consistent with the signal sent in the first stage (i.e. the transfer of the first half) that the second half be sent. By doing so the principal can reciprocate (reward) the agent's trustworthiness, however, in contrast to the trust game without having to sacrifice any additional material payoff. In other words, "cooperative" principals are naturally self-selected into eventual compliance with the contract. Thus, selfish players have a pecuniary incentive, while reciprocal players have an intrinsic motivation to cooperate.

The method of indenture can be applied to real-world situations. For instance, employers invest in a management trainee with training (i.e., the first half of indentured note), and a positive or negative reference letter (i.e., transferring or keeping the completing half of indentured note), in exchange for a minimum term of work after the training phase.[4] A second example is the buying of a car by making use of a bank loan. To collateralize the loan, banks usually keep the car registration documents, without which the car cannot be sold. These documents (the second part of the banknote) are handed out by the bank only if the owner of the car has repaid the loan (the effort) in full.[5]

It is important to test the efficacy of indenture as a self-enforced contract device, its robustness across parameter variations, and to understand the method and its limitations – when theory and empirical evidence do not (fully) coincide. In practical terms, laboratory experimentation allows us to test such a mechanism design *ex ante* at low costs, relative to the *ex post* costs involved in natural experiments.[6] Based on laboratory experiments, our paper compares cooperation rates in the IG with that in a three-stage centipede game (CG) with similar parameter values (e.g. gains-from-trade). Theory predicts no cooperation in the CG. We interpret the cooperation observed in the CG as a benchmark for the 'natural rate of cooperation', defined as the rate of cooperation observed in a game where individuals have the (pecuniary) incentive to unilaterally deviate, i.e. not cooperate.

The rest of the article is organized as follows: Section 2 presents a further analysis of the IG and CG; Section 3 describes the experimental design; Section 4 reports our results; Section 5 discusses and concludes, unfolding that, overall, indenture is effective.

2. Theoretical Background

The IG is a three-stage game, following Kritikos and Bolle (1998): Two parties can potentially enter into trade, exchanging a service (by the agent) for a payment (by the principal). Principals and agents make non-binding agreements.[7] Players cannot be forced to comply with the "agreement" (the word "agreement" is a misnomer if only one party wishes to engage in trade). In stage 1, a principal can *initiate* a contract by indenturing a banknote of value e by tearing it in two. A principal chooses whether to cooperate by sending one part of the indentured banknote (the first half) to the agent (call this action c_1), or to take the outside option and keep the entire banknote (call this action n_1).

Tearing the banknote in two renders both pieces worthless, when separated. The banknote regains its value only when the principal sends the agent the matching and completing half (the second half). In stage 2, the agent may provide (c_2) or refuse to provide the service (n_2). Upon refusal, there is no "contract", and the agent keeps b, the outside option, which is the cost he has to incur in providing the service, where $b < e$. In stage 3, if the service is provided, the principal receives a, the value of the service to him, where $a > e$. Here he then has the choice between transferring (c_3) or withholding (n_3) the second part of the indentured banknote.[8] Thus, in the IG, in stage 1, the principal virtually "gives up his entire stake" (although only the first half is transferred, it no longer holds pecuniary value for the principal) to the agent (albeit the intermediate payment in hand holds no pecuniary value for the agent). In the final stage, the principal is indifferent between transferring and withholding the completing half. Figure 1a describes the IG.

<Insert Figure 1a about here.>

Let us consider the principal's strategies. The principal can, in stage 1, choose between two actions, namely between initiating a contract or not initiating it. In stage 3, the final stage, the principal has the choice between two further actions, namely between transferring or retaining the second part of the banknote. Given that the agent also has to choose between two actions in stage 2, namely to provide or refusing to provide the service, the principal has the following set of four strategies at hand if he enters the subgame of indenture, by sending the first half of an indentured banknote: I) always transfer the second half regardless of the agent's choice; II) never transfer the second half regardless of the agent's choice; III) transfer the second half only if the agent had not provided the service, or; IV) transfer the second half only if the agent had provided the service.[9]

Backward induction identifies four subgame-perfect equilibria. If the principal chooses strategy IV, it is a mutual best reply for both to take cooperative actions throughout the game, leading to outcome (c_1, c_2, c_3). If the principal chooses any of the other three strategies, the best reply of the agent is to defect, and the principal is better off not initiating the contract, leading to outcomes (c_1, n_2, c_3), (c_1, n_2, n_3) and (n_1, n_2, n_3). Thus, players have conflicting interests in this game.

Amongst the multiple equilibria, the equilibrium selection concept of *forward induction* (van Damme, 1989) selects (c_1, c_2, c_3) as the *unique stable equilibrium*. The logic of forward induction requires the following weak property to be satisfied: "[…] in generic 2-person games in which player *i* chooses between an outside option or to play a game Γ of which a unique (viable) equilibrium $[\psi]^*$ yields the player more than the outside option, only the outcome in which *i* chooses Γ and $[\psi]^*$ is played in Γ is plausible" (p. 485 in van Damme, 1989). (We replace 'e^*' in van Damme's original text with 'ψ^*' to avoid confusion with our use of *e* to denote the value of the banknote.) In our context, Γ is played when the principal sends the first half of the indentured note. A principal who sends the first half of the indentured note rejects the outside option at the same time. This sends the agent a signal on how he wants the rest of the game to be played: He has chosen strategy IV. The best reply of the agent is to cooperate, because (c_1, c_2, c_3) constitutes the only equilibrium that yields higher payoffs to both players than the outside option. All other equilibria yield less. Otherwise, the principal would have chosen the outside option. It is consistent with this equilibrium strategy that the principal transfers the second half of the indentured note in the final stage.

The efficacy of the IG can be compared against a benchmark where cooperation is not incentive-compatible. We use a three stage version of the well known *centipede game* (*CG*), to benchmark the natural rate of cooperation (see Figure 1b). Here principals have no access to indenture. Instead, the principal can transfer a *prepayment* (of half the pecuniary value of total payment – not half the fiduciary document) to the agent when initializing the contract, and the second half upon delivery of the service. IG and CG are similar in that no party is forced to honor their dues (i.e., payment upon service, or service upon payment). In the CG, however, the unique equilibrium by backward induction is that the principal chooses not to initiate the contract, taking the outside option, right from stage 1 (Rosenthal, 1982).[10] Nobody cooperates.

<*Insert Figure 1b about here.*>

Both games have the same information structure and order of moves, and can be parameterized to have the same valuations and costs of service, outside options, and potential gains from trade. But, the crucial difference is in the available actions and in turn the corresponding payoffs for outcomes (c_1, n_2, n_3) and (c_1, c_2, n_3). There is an incentive and temptation to defect in every stage of the CG, but not in the IG. In other words, there are only strategic incentives to cooperate in the IG – the predictions are polar opposites. Cooperation is, however, often observed in experiments on the CG (McKelvey and Palfrey, 1992). People cooperate because they make errors, are altruistic or mimic altruistic play (McKelvey and Palfrey), or trust and reciprocate (Dufwenberg and Kirchsteiger, 2004 – as discussed below). Because the principal's available actions are different across games, and incentives are different across stages, we compare behavior on a game-by-game rather than stage-by-stage basis, for how much cooperation we can expect with or without indenture.

Reciprocity can also predict (c_1, c_2, c_3). Consider Dufwenberg and Kirchsteiger's (2004) intentions-based model of reciprocity in extensive form games. They define kindness (of i towards j, where $i \neq j$) as an intention, a function of the difference between actual payoffs π_j and fair payoffs π_j^{fair}, i.e.,

$$\kappa_{ij}(x_i(h), y_{ij}(h)) = \pi_j(h) - \pi_j^{fair}(h), \qquad (1)$$

where x_i is i's strategy, y_{ij} is i's beliefs of player j's strategy, and updated given a history h (in this case stage number 1, 2, 3). With reciprocity, a payoff resulting from intentions of positive (negative) kindness is responded to, i.e. matched, with positive (negative) kindness. Consider

$$U_i = \pi_i + \sum_j R_{ij}.\kappa_{ij}.\lambda_{iji}, \qquad (2)$$

a utility function where R_{ij} is the reciprocity parameter and λ_{iji} is i's belief of j's kindness to i. It increases (decreases) when the 'signs' are (not) matched. A strategy profile that maximizes U_i for all h and i when beliefs and strategies match is a *sequential reciprocity equilibrium* (SRE).

Dufwenberg and Kirchsteiger (2004) show that among the existing equilibria in the CG the unique sequential reciprocity equilibrium is to cooperate: Cooperation by the principal in stage 1 yields a positive profit for the agent in stage 2, which if reciprocated by the agent in stage 2 will increase the principals profit, and in turn the principal can reciprocate by sending the second payment to the agent in stage 3. In the IG, principals playing c in stage 1 would in material terms be indifferent between playing c and n in stage 3. But, a principal with $R_{ij} > 0$ will positively reciprocate the positive kindness of an agent who plays c in stage 2 with positive kindness by playing c in stage 3. The same principal will reciprocate the unkindness of an agent who plays n in stage 2 with unkindness by playing n in stage 3. Given a complying agent he prefers c_3 to n_3 because $U_i(c_1, c_2, c_3) > U_i(c_1, c_2, n_3)$, while for a non-complying agent he prefers n_3 to c_3 because $U_i(c_1, n_2, c_3) < U_i(c_1, n_2, n_3)$. Unfolding backwards, the agent who recognizes that a reciprocal principal will respond to the agent's c in stage 2 with c in stage 3 (if c was also played in stage 1) will therefore decide to play c in stage 2. In turn, the principal knowing that the agent will play c in stage 2 (if he plays c in stage 1) will play c in stage 1. Thus, without invoking forward induction, (c_1, c_2, c_3) holds if the principal is infinitesimally reciprocal, even if the agent is not. Cooperation is sustained even if we impose transaction costs in stage 3, given that reciprocal preferences, or risk loving, are sufficiently strong.[11]

As with most experimental games, the IG *when implemented experimentally* is one of incomplete information about player types. We consider the behavioral argument that a player can make decisions based simply on the prior that some but not all co-players will cooperate (for a similar approach in the centipede game, see McKelvey and Palfrey, 1992), on the basis of the cost-benefit ratios for each player. A risk neutral principal initiates the contract in stage 1 if he expects it to be sufficiently profitable, i.e. if the perceived probability of meeting an agent cooperating in stage 2 is $p \geq e/a$ (with a being the principal's valuation of the service). Likewise, a risk neutral agent will only work if the perceived probability of the principal cooperating in stage 3 is $p \geq b/e$ (with b being the agent's cost of providing the service).[12] In the CG, the principal's (agent's) perceived probability of meeting a cooperative agent (principal) must be $p \geq ke/a$ ($b/[(1-k)e]$), where $k \leq 1$ is the fraction of the prepayment over the full payment (here $k = ½$). Now assume a twice continuously differentiable utility function where $u' > 0$, e.g. $u(\pi) = 1+\pi^{1-\rho}$, where $\rho = -\pi u''/u'$ is the Arrow-Pratt coefficient of relative risk aversion (Hirschleifer and Riley, 1992). Assuming $p \geq e/a$ for principals and $p \geq b/e$ for agents, risk averse principals and agents, for whom $u'' < 0$, will not cooperate if ρ is sufficiently large such that $pu(a - e) > u(e + r)$ for principals and $pu(e - b) > u(b + r)$ for agents, where $r = \rho\sigma^2/2$ is a risk premium.[13]

Without strategic reasoning, less is at stake for the principal in stage 1 of the CG, i.e. $e/2$, than in the IG – if the full value of an indentured banknote is not refundable, i.e. e (0), if the agent plays n_2. And, more is at stake for the agent in the IG than CG, as he would only have received $e/2$ instead of e. But with strategic reasoning, forward (backward) induction assigns a degenerate probability of 1 (0) on cooperation in every stage of the IG (CG) along the equilibrium path, and thus from this perspective there is far less risk in the IG than the CG. With insufficiently strong reciprocal motives in the CG, there is a positive probability of defection (see Dufwenberg and Kirchsteiger, 2004, for the conditions under which we expect cooperation); thus, the probability of cooperation is $p < 1$. In contrast, in the IG, if the distribution of reciprocal types is non-atomic and continuous, there is a degenerate probability of cooperation $p = 1$ if $R_{ij} > 0$.

3. Experimental Procedure

The experimental games closely follow those described above. In both experiments, principals received specimen banknotes, and agents received vouchers indicating the value of their service. These were all placed, collected and redistributed (to the relevant subject) in envelopes, thus maintaining privacy and anonymity. We fixed e = 20; each principal was provided with a "DM 20 banknote" which is equal to little more than 10 Euros. Principals and agents played IG's (Figure 1a) varying in values for the service. The treatments differed according to following parameters for IG(a,b): IG(30,10), IG(25,5), IG(25,15), and IG(40,15). These variations allow us to test the robustness of indenture under different parameters.[14]

The *centipede game* (*CG*) in Figure 1b was parameterized so that the gains from cooperation, compared across the initial and terminal nodes, are similar to IG(30,10). The procedure for the CG was identical to that of the IG, except that in stage 1 of the CG, the principal could choose to make a prepayment of "10 DM" (instead of tearing the banknote in two and giving the one half to the agent in the IG) if he wanted to start the contract, and in stage 2 whether to send the agent a second payment of "10 DM" (instead of giving the other half of the note to the agent in the IG).

For the IG, parameters differed across sessions, and kept constant within sessions (between-subject design). Principals received no refunds for indentures made to agents refusing service: Doing otherwise would likely result in a deluge of 'risk-free' cooperative actions by principals. The game had complete information on payoffs. The same game was repeated seven times, with random and anonymous pair-wise re-matching in each round. The number of periods was announced at the beginning of each session. Subjects received feedback on the actions and outcomes relevant to their pair-wise match. This procedure implements the one-shot nature of tasks, and prevents unnecessary confounds from reputation and supergame effects. By repeating a game with different co-players, subjects may update their priors of the distribution of player types, as well as converge to the equilibrium play.

The experiment was conducted in the European University Viadrina, Germany. A total of 160 undergraduates participated, with 32 subjects in each of the five sessions; each session was partitioned into four smaller sub-sessions of eight subjects each, with four principals randomly re-matched with four agents for each new round. Partitioning maintains independence across sub-sessions, while having large sessions reduces possible confounds from indirect reciprocity from repeated re-matching in small groups. Subjects were recruited via verbal and written announcements. Upon arrival, the subjects were randomly assigned roles as principals or agents. Roles remained unchanged throughout the session. There were 16 principals and 16 agents in each session. Subjects were placed in two separate rooms, depending on role. Instructions were read aloud to inform subjects of the uniformity of tasks. They were also provided with these instructions on a printed sheet. The appendix contains an example of the instructions, making use of the case of the IG(30,10) game for principals.

The game was presented in an intuitive buyer-seller context. Terms such as ‘cooperate’ and ‘defect’ were avoided. Before making decisions, subjects answered control questions to check their understanding. The session started after all subjects had given correct answers. Subjects were given copies of banknotes and corresponding values for the ‘service’ which were transferred back and forth via envelopes. Two agents and two principals were randomly chosen to receive payments at the end of each round. The average payoff per subject was about 13 Euros including a small show-up fee of 2.50 Euros. Each session lasted 60-90 minutes.

4. Results

Efficacy. Table 1 provides an overview of the observed behavior. In stage 1, principals decided to offer contracts by sending the first half of the indenture to their potential trading partners in 94% of all cases. For stage 2, agents who were offered a contract, accepted it and delivered the service in 87% of all cases. A large proportion of principals and agents mutually agree on a contract. In stage 3, principals who had received the service completed the contract by transferring the completing half in 97% of all cases. Completed transactions were observed in 79% of all the games played. The efficacy of indenture and also forward induction as a solution concept received support both at the levels of individual stages and entire games. Thus, most importantly, the observed behavior is in line with the forward induction solution, and testimony to the efficacy of the IG. We will test this in further detail in the next sub-section.

The behavior observed in stage 3 is consistent with the strategy predicted by forward induction, and in line with behavioral theories such as the approaches to reciprocal behavior. Perfectly selfish principals, at this stage, would be indifferent between transferring and withholding the completing half. Almost all principals transfer the completing half,[15] suggesting that social preferences (e.g. altruism, fairness, and in particular, reciprocity) can serve as a good tie-breaker in such cases of indifference, if they were not already decided in the first stage by forward induction.

<Insert Table 1 about here.>

Performance. Figure 2 shows that IG(30,10) performs, in terms of completed contracts, about as well as the CG in the first round, but way better over time and in the final round. The rate of completed contracts increases from 0.69 to 0.88 in IG(30,10) (mean 0.76), while it decreases from 0.63 to 0.06 (mean of 0.36) in the CG. Mann Whitney U tests (based on the average per sub-session) find the difference in initial round completed contract rates insignificant ($z= –0.32$, $p=0.38$; 1-tailed), while differences between conditions in terms of penultimate round cooperation ($z=-1.821$, $p<0.05$) – a test of robustness in view of possible endgame effects (Selten and Stoecker, 1986) – and final round cooperation rates are statistically significant ($z= –2.40$, $p<0.01$); so is the difference in overall completed contract rates ($z= –2.32$, $p=0.01$).[16]

Table 2 reports binary probit regressions of completed contracts COMCON (=1 if contract was completed, =0 if otherwise), clustering errors by sub-session to control for the non-independence in data due to random re-matching and interactions,[17] on ROUND (1-7), to capture and compare the evolution of behavior over time for CG and IG(30,10).[18] Model 1 (based on the CG sub-sample) shows that the probability of completing a contract decays over time in the CG ($b= –0.20$, $p = 0.01$) towards the 0% mark. Model 2 (based on the IG(30,10)) shows that the ROUND coefficient is positive but statistically insignificant ($b=0.09$, $p=0.145$). Model 3 is performed on the pooled data, and adds an interaction variable ROUND by COND (=1 if IG(30,10) and =0 if CG). The COND coefficient confirms that there is no significant difference between the rates of completed contracts in the two games for the initial round. The slope for IG(30,10) is significantly different and of a different sign and larger absolute value than that for CG ($b=0.29$, $p<0.01$).

<Insert Figure 2 about here.>

We find strong evidence that there is more cooperation with indenture than without.

<Insert Table 2 about here.>

Risk attitudes and strategic incentives. Here, we look at a possible explanation for the variation of cooperation rates across treatments, per role: risk, as embodied by payoffs, vary across treatments (see section 2). The number of contracts accepted by agents decreased from 96% in IG(25,5), to 88% in IG(30,10), 85% in IG(40,15), and 81% in IG(25,15). Based on our analysis below, agents do not accept contracts simply based on the (possible) signal sent by the indenture. Our data also reveals that a lower profit margin (i.e., the revenue relative '*e*' to the cost of the service for the agent '*b*') reduces the agent's willingness to transfer the service, even though cooperation is always a best-reply in the IG.

<*Insert Table 3 about here*>

Similarly, we may expect in stage 1, that the probability of a principal to initiate contracts will decrease with the perceived probability threshold, defined as the minimum probability of meeting a cooperative co-player required to make the expected gain of cooperation positive, *e/a*. The rate of contracts offered rose from 88% in IG(25,15), to 89% in IG(30,10), and to 99% in IG(40,15). This relationship, however, does not hold for IG(25,5) where we observe 99% of principals offering contracts; it should in this case have a similar cooperation rate as IG(25,15) – but it does not.

A possible explanation is as follows. In the IG (25,5) the perceived probability threshold for agents to not cooperate is low. In turn, the probability of agents unwilling to cooperate is low. Table 4 reports binary probit regressions of CWORK (=1 if work was performed if contract was offered, =0 if work was not performed when contract was offered), clustering errors by sub-session, on *e/a* and *b/e*.[19] The effect of *b/e* is negative and significant ($p<0.05$), whereas that of *e/a* is statistically insignificant ($p=0.30$). For a sufficiently high perceived probability of meeting a malicious principal, the expected profits from cooperation must be sufficiently high to encourage cooperation by agents. Cooperation rates are negatively correlated with risks, conversely speaking, positively correlated with potential profits.

<Insert Table 4 about here.>

Principals, anticipating this and being the first movers, had good reasons to always offer a contract. Table 4 reports binary probit regressions of INDENT (=1 if first half of the indenture was offered, =0 if otherwise), clustering errors by sub-session, on *e/a* and *b/e*. The effects of *e/a* and *b/e* are both negative and significant (both $p<0.05$). The principals' behavior must also be considered together with their anticipation of how agents will respond to the indenture, given an agent’s expectation of meeting a malicious principal and the potential profit from trade. The principal’s strategic position allows for such anticipations to be used in the decision-making process. It, thus, provides support for anticipation and backward induction reasoning, beyond cases explainable by forward induction. If we restrict the sample and consider all cases except IG(25,5), there is a negative and significant relationship between *e/a* and average principal cooperation rates ($p<0.001$), and the strength of *b/e* is less than in the unrestricted sample, and its coefficient is positive but only of marginal statistical significance ($p<0.1$, 1-tail), in support of the importance of the principal’s anticipation with respect to the agent’s behavior in IG(25,5).

To summarize, the probability of an agent offering the service increases with the (expected) profit margin. With respect to principals, the number of contracts increases with potential gains from trade. Principals anticipated high rates of cooperation by agents when agents were able to gain high profits and so matched their behavior to these expectations.

5. Discussion and Conclusion

This paper experimentally tests to what extent it is possible to realize an exchange a principal has arranged with an agent by making use of a new kind of contract – the indenture game. In an indentured contract the principal can promise payment-on-delivery, where he tears a banknote in two, transfers the first half to the agent as "prepayment", and then the completing half if the agent delivers the service. To analyze the efficacy of this contract in comparison to a baseline treatment, we have tested very simple versions of the IG and CG, both played over three stages. Our results show that high cooperation rates can be achieved when contracts are designed as IG, even in a one-shot environment where reputation does not count. Overall and particularly in the final round, cooperation rates in the IG are significantly higher than in the CG where the exchange will take place only if principals and agents mutually trust and reciprocate.

The transfer of an indentured banknote in return for an agent's service is an incentive-compatible self-enforcement device when complete contracts cannot be written. Agents who realized that their mutual best reply in this game was to cooperate, offered the requested service, while principals anticipating this transferred the first half of the indenture. It would also be possible to explain the results in terms of risk attitudes, the flip side of the coin, when we compare incentive-compatible (such as the IG) with non-compatible contracts (such as the CG): with strategic reasoning, principals face less risk in the IG than in the CG, where they are sending value in exchange for value, while in the IG principals are sending at the first stage a signal which is worthless of its own but only binds the principal. Similarly, in the second stage the risk of the agent is lower in the IG than in the CG to transfer the service, because again the principal incurs no cost to transfer the second part of the indenture at the last stage of IG while it does incur costs to the principal to send the final payment at the CG. Judging by how the observed cooperation rates are always higher than the necessary probability threshold but often below 100%, we can infer that there are players who are sufficiently risk averse.

These observations need to be discussed from several points of views. First of all, the high rates of cooperation in the IG could be interpreted as support for forward induction as an equilibrium selection criterion, because behavior follows in the suit of its prediction. However, the extent to which the IG is effective increases with the potential profit an agent can derive from cooperation, even though forward induction selects the cooperative equilibrium in all treatments. For principals, it is not as straightforward. Their strategic position allows them to play a crucial role, when they had to decide whether or not to enter the indentured contract. Knowing that the agent can stand to gain more, principals were convinced that sending the first half is a safe move; their potential profits, although relatively low, will be gained with a high probability.

This can be attributed to the high degree of strategic “complementarity”, which cuts both ways. An agent should cooperate as and when a principal offers a contract. Likewise, a principal who considers the agent’s high potential gains from cooperation can expect his offer to be accepted with a high probability. In the other cases, a principal’s readiness to cooperate was observed to increase with potential profit. This observation shows the limit of the IG: One should be cautious when applying the IG to cases where the potential gain of an agent might be very low, relative to his cost, as refusals by agents to accept contracts might give rise to losses suffered by principals upon “let-down” (and in turn, efficiency losses result). A method to circumvent this problem is by providing social history of previous interactions, such as a “track record”, to signal reputation.

On another note, the observed cooperation is also explainable by social preferences such as trust and reciprocity whose predictions coincide with forward induction here.[20] We have tested the extent to which introducing extrinsic incentives to a population with reciprocal players might result in possible negative effects (via crowding out), which in turn would diminish the efficacy of indenture. As it is reasonable to assume that all kinds of player types had participated in the experiment, the observed behavior in the IG allows for the conclusion that this contract design is an effective solution for both selfish and reciprocal players. Insofar as there are intrinsically motivated players, we have not observed strong evidence indicating any form of crowding out of intrinsic motivations. In contrast, cooperation increased with the amount of extrinsic incentives provided. By implementing the contract with the first half as trust, and payment with the completing half as reciprocity, the IG seems to be a game structure which is appealing to both intrinsically and extrinsically motivated types of players. To this effect, some principals and agents cooperate, in the words of Frey (1997), "not just for the money". It also works for the others -- those who cooperate just for the money.

The stability of the IG over time makes it an attractive policy and contract tool, countering the problem of crowding-out of intrinsic motivation with contracts purely based on extrinsic control. As the research of Falk and Kosfeld (2006) clarified, the main problem of such contracts is that agents react negatively to control measures of principals because their active decision to control agents' performances contains a signal of distrust towards the agents. Most agents being confronted with such messages of distrust react with "control-averse behavior". The IG is a different contract device as it is able to combine both messages 'trust' and 'control' in its design. This outcome makes clear that it is important to increase the choice set of principals so that they do not have to choose between contracts where they are either only able to control (and thus distrust) or only to trust the agent (without controlling him).

Last but not least, our experiment also reveals that contracts based on trust and reciprocity – in recent experimental literature suggested as of being a feasible solution to principal-agent problems – lead to relatively high cooperation rates only in strict one-shot environments. In our experiment we also observed high rates of cooperation between subjects in the first round of the centipede game. However, with the game being played repeatedly between changing subjects, the willingness to cooperate dropped dramatically. Insofar our experiment confirms similar findings of Zauner (1999).

Our experiment's primary goal was to test the efficacy of indenture as a self-enforced contract. It has limitations, which can be investigated with further research. One can attempt to disentangle social preferences and strategic incentives, for example, by specifying type separating payoff structures, or eliciting beliefs of co-player's actions, types and intentions. One can also allow principals or agents to choose from a variety of contracts (with respect to payoff parameters) to offer (or accept), instead of being constrained to one contract. Such a design enables a deeper analysis with respect to potential crowding out effects which could occur in the IG, as well.[21] For future research, one can allow for structured communication between principal and agent to mutually decide on which one of these contracts to use. Also, market mechanisms such as auctions can be used to optimally implement contracting between parties with different costs and reservation values, in the framework of indentured contracts.

To conclude, this experiment provides first evidence that individuals can be induced to cooperate when indenture can temporally delay incentives, *ex ante* serving as a signal to follow through with payment-upon-delivery.

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Endnotes

[1] A large body of literature deals with contractual situations under unverifiable information. For seminal papers see *inter alia* Holmström (1979) Grossman and Hart (1983), Shapiro and Stiglitz (1986), Laffont and Tirole (1988), Hart and Moore (1988), Aghion, Dewatripont and Rey (1994). See Milgrom and Roberts (1992) for a survey.

[2] Experimental evidence indicates that extrinsic incentives may substitute rather than complement intrinsic motivation (Falk, et al., 1999), or even crowd out voluntary cooperation (Gneezy and Rustichini, 2000; Fehr and Gächter, 2002).

[3] For formal models of reciprocity, see Rabin (1993), Dufwenberg and Kirchsteiger (2004), Bolle and Kritikos (2006), Falk and Fischbacher (2006). A first model based on voluntary cooperation instead of incentives is provided by Holmström and Milgrom (1991).

[4] As to the final move the employer is obliged by law to provide every employee with a reference when he quits. The principal has only the choice between a positive and a negative reference which is why he is indifferent at the final stage.

[5] The second example fits with the IG only with respect to the buyer's option of selling the car. Further examples can be found in i) history or in ii) thrillers. Ad i) In the beginning of the 19th century, the indenture was commonly used in England as a form of sealed contract or agreement, especially where land and buildings were concerned. Ad ii) There is a large number of detective stories or thrillers where a banknote is in fact torn in two, e.g. in the film "Eyes Wide Shut", Bill Harford convinces a taxi driver to wait for his return at a secluded spot with an incentive of $100, by tearing the bill in two and passing the taxi driver half, promising the other half on his return.

[6] It should be pointed out that it might be necessary to run both experimental tests in the

laboratory and natural experiments in the field in order to be able to derive consistent policy recommendations, see Levitt and List (2007).

[7] For simplicity, variables such as investment, wage, effort or quality levels are not considered here. The service is an indivisible good, with a fixed quality known to both parties.

[8] Kritikos and Bolle (1998) and Kritikos (2000) also discuss conditions under which agents expect to receive the second indenture from the principal.

[9] One may interpret these four strategies as being 'altruistic', 'malicious', 'perverse', and 'reciprocal', respectively. On another note, in total the principal has eight strategies at hand, four strategies if he initiates the contract and four more strategies (of distrust) when he does not initiate the contract at the first stage of the game.

[10] Other experiments on the centipede game (e.g. Fey et al., 1996; McCabe et al., 1998; Zauner, 1999) are similar in nature to the centipede game, which we will use here, but the design of the experiments are different in terms of stages and payoffs and, thus, cannot serve the purpose of a comparable control treatment in this investigation.

[11] Trust invested by the principal in stage 1 of the IG yields the agent a psychological payoff, prompting reciprocation with work in stage 2. If the principal plays c_1, lowering intermediate payoff $\pi_i(1)$, relative to before the indenture, with the positively kind intention of increasing $\pi_j(3)$, the agent can play c_2 to decrease $\pi_j(2)$ to increase $\pi_i(2)=\pi_i(3)$ and maximize $\pi_j(3)$ and in turn U_j if the principal follows through with kindness by playing c_3.

[12] The limit b/e holds for the case that the principal does not choose the perverse strategy, where he offers the second part only if the agent does not transfer the service. Otherwise, the probability of meeting a "perverse" principal needs to be added to b/e. For risk averse persons a risk premium has to be added to e/a and b/e, which has to be exceeded by the payoffs of the IG,

to make an agreement to this contract profitable.

[13] Risk premium is defined as the proportion of wealth one will forgo to obtain the outside option with certainty.

[14] Experimental evidence indicates that extrinsic incentives may substitute rather than complement intrinsic motivation (Falk, et al., 1999), or may even lead to a crowding out of voluntary cooperation (Gneezy and Rustichini, 2000; Fehr and Gächter, 2002). The method of indenture attempts to circumvent this (see section 2).

[15] In the entire experiment, there were only four isolated cases where principals transferred the second half of the indentured note, even though the agent did *not* work (Treatment 1: 1/12; Treatment 2: 2/17; Treatment 3: 1/19).

[16] Further tests corroborate: the difference between the average number of completed contracts in both games over the block of rounds 1-3 is only marginally significant ($z=-1.479$, $p<0.1$), whereas the differences in and blocks 4-6 ($z=-2.178$, $p<0.05$) and 5-7 ($z=-2.337$, $p<0.01$) are significant on a higher level.

[17] Using binary probic regressions, controlling for individual specific random effects, without clustering errors by sub-sessions, we find similar results, except that the round coefficient in model 2 is marginally significant at $p<0.1$ (1-tail).

[18] We do not analyze stage-by-stage behavior, due to the difference in payoff relations, as explained in section 3.

[19] Using binary probit regressions, controlling for individual specific random effects, without clustering errors by sub-sessions, we find similar results. The same applies to the regressions reported below.

[20] Similar results of higher shares of cooperation (in games where forward induction could be

applied) are found even with no such "coincidence", e.g. Brandts and Holt (1992), who applied a forward induction solution to the Battle of the Sexes Game (e.g. Cooper et al., 1993; Brandts and Holt, 1995 or more recently Huck and Müller, 2005). Van Huyck et al. (1993) found similar support when the outside option was auctioned; the outcome of the outside option is thus endogenized. For a related discussion of Forward Induction in experimental games, see Ochs (1995).

[21] For instance, if a principal has the choice between sending half of a payment or the indenture of a full payment we cannot exclude that sending an indenture may signal less trust to the agent than sending half of the payment and hence lead to crowding out effects in the IG.

Table 1

Mean Cooperation Rates

Treatment		Stage 1	Stage 2	Stage 3	Completed
IG (30,10)	Mean	0.89	0.88	0.97	0.76
	N	112	100	88	112
	S.D.	0.31	0.33	0.18	0.43
IG (40/15)	Mean	0.99	0.85	0.97	0.81
	N	112	111	94	112
	S.D.	0.09	0.36	0.18	0.39
IG (25,15)	Mean	0.88	0.81	0.94	0.66
	N	112	98	79	112
	S.D.	0.33	0.40	0.25	0.48
IG (25,5)	Mean	0.99	0.96	1.00	0.95
	N	112	111	106	112
	S.D.	0.09	0.21	0.00	0.23
Total	Mean	0.94	0.87	0.97	0.79
	N	448	420	367	448
	S.D.	0.24	0.33	0.17	0.40

Table 2

Binary Probit Regressions of Completed Contracts over Time*

	Model 1	Model 2	Model 3
Constant	0.413*	0.363	0.413*
	(0.232)	(0.447)	(0.215)
ROUND	-0.202**	0.878	-0.202**
	(0.087)	(0.083)	(0.081)
COND			-0.050
			(0.466)
ROUND by COND			0.290***
			(0.112)
Log pseudolikelihood	-67.862	-60.966	-128.828
n	112	112	224

* Statistical significance at p<0.1(0.05)[0.01] denoted by *(**)[***], 2-tailed. Clustered by sub-session, with 4 clusters for models 1 and 2, and 8 for model 3. Model 1 is for the CG, Model 2 for the IG(30,10), and model 3 for the pooled data.

Table 3

Perceived Probability Thresholds and Mean Cooperation Rates

Treatment	e/a	Stage 1	b/e	Stage 2
IG (25,15)	0.80	0.88	0.75	0.81
IG (40,15)	0.50	0.99	0.75	0.85
IG (30,10)	0.67	0.89	0.50	0.88
IG (25,5)	0.80	0.99	0.25	0.96

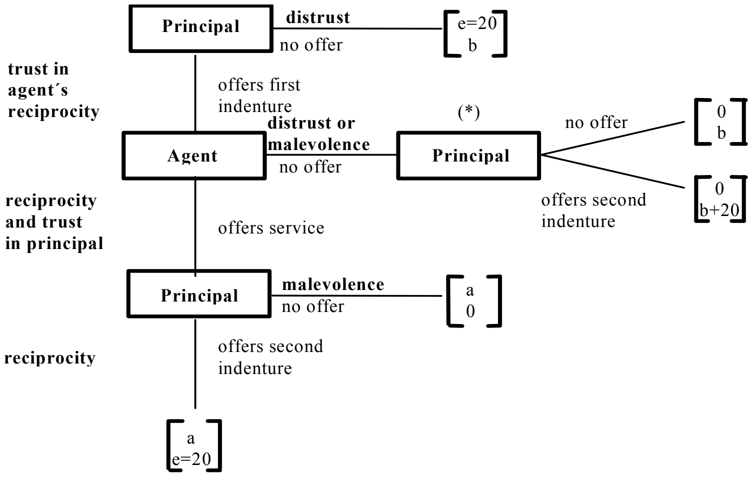
Table 4

Binary Probit Regressions of Perceived Probability Thresholds and Cooperation*

	CWORK	INDENT-U	INDENT-R
Constant	2.437***	3.786***	3.050***
	(0.917)	(1.034)	(0.954)
e/a	-0.5	-2.181**	-4.061***
	(0.943)	(0.993)	(1.165)
b/e	-1.524**	-1.214**	1.800
	(0.735)	(0.608)	(1.211)
Log pseudolikelihood	-145.362	-99.837	-86.048
n	419	448	336

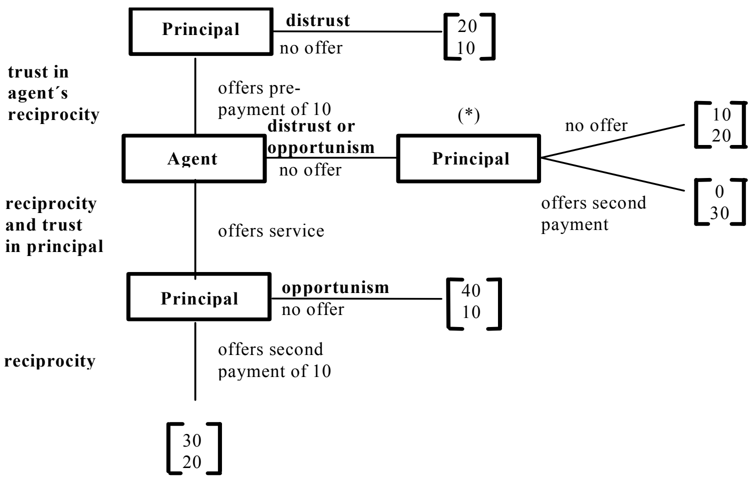
* Statistical significance at p<0.1(0.05)[0.01] denoted by *(**)[***], 2-tailed. Clustered by sub-session, with 16 clusters for CWORK and INDENT-U, and 12 for INDENT-R. INDENT-U is based on the restricted data, and INDENT-R the unrestricted data (without IG(25,5)).

Figure 1a: The Indenture Game



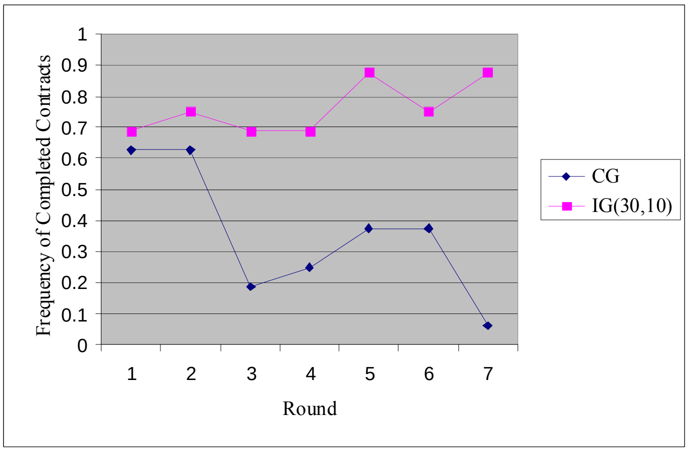
Node (*) can be replaced by (0,*b*) if one assumes that a principal does not play the altruistic strategy of offering the second half even without receiving the service. This assumption is also tested with our experimental design.

Figure 1b: The Centipede Game



Node (*) can be replaced by (10, 20) if one assumes that a principal does not play the altruistic strategy of offering the second 10 DM even without receiving the service. This assumption is also tested with our experimental design.

Figure 2: Evolution of frequency of completed contracts in CG and IG(30,10) over Time



Appendix

Instructions for K

Password:........ Pseudonym:...........

You take part in an experiment between two parties, named V and K. A person V has a stamp to which he assigns a value of DM 10. A person K assigns a value of DM 30 to the same stamp. Both agree that V will sell the stamp to K at a price of DM 20.

You are **K**! Your number is ......

Step 1

You may (but you do not have to) tear the banknote in two parts and transfer half of it to V. If you keep your banknote, the exchange is over. If you tear the banknote and transfer one part of it to V, the exchange goes on:

Step 2

V may (but does not have to) send you his/her stamp.

Step 3

You may (but you do not have to) send the second part of the banknote to V.

If you have a complete banknote of DM 20, you are entitled to DM 20. If you have the stamp you are entitled to DM 30. If V has the stamp, he/she is entitled to DM 10.

This experiment will be repeated six times and you will be randomly re-allocated in each round to another person V. All pairings are and will remain anonymous. Neither you nor V will now or after the session be informed about each other's identity.

In each group 2 different participants will be randomly chosen after each round to receive the appropriate payment.